(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 300 218 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.04.2003 Bulletin 2003/15

(51) Int Cl.7: B24B 23/03, B24B 41/047,
B24B 7/18

(21) Application number: 02256865.3

(22) Date of filing: 02.10.2002

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
IE IT LI LU MC NL PT SE SK TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 02.10.2001 GB 0123657

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(54) Worktool

(57) A worktool comprises a principal drive shaft (1) with a sun gear (2) attached thereto. At least two planetary gears (3) are distributed about the circumference of the sun gear (2) at substantially equal angular separation. A carriage (4) constrains the planetary gears (3) such that they maintain their angular separation about the axis of the principal drive shaft. Each planetary gear (3) has an eccentric axis (5) in addition to its rotational axis constrained by the carriage, such that each planetary gear (3) can drive, in use, a rotating work-piece engaging surface (6) around the respective eccentric axis (5). There may be a phase difference of $2\pi/n$ radians (n being an integer equal to the number of planetary gears) between any two eccentric axes.

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] This invention relates to worktools and, in particular, rotating worktools that engage with a surface, such as sanders and polishing machines.

[0002] Known orbital and random-orbital worktools, such as sanders, function by driving an abrasive surface in a circular path about principal drive shaft. A surface may be of fixed orientation or free to rotate about an eccentric axis, according to whether the resulting motion is required to be orbital, or random-orbital respectively. Such work tools suffer from vibration. Vibration in such systems has two distinct components, dynamic (which results from unbalanced centripetal acceleration) and frictional (which results from the translating frictional forces between the working surface of the tool and the work piece).

[0003] Dynamic imbalance can normally be corrected by distributing counter weights at particular axial, radial and phase positions on the drive axis of the worktool. However, this approach relies on the working surface of the tool, such as the sanding platen, and any attached replacement component being of constant mass. This means that changing the platen or replacing the working material can often cause unwanted vibration.

[0004] Vibration experienced in use also often arises from translating frictional forces between the abrasive surface, acting so as to make the eccentric drive axis the centre of rotation. In the worst case, these vibrations can be of an amplitude equal to the shaft eccentricity, in the case that the principal drive shaft orbits the stationary eccentric shaft.

[0005] Frictional vibration increases with increasing contact force, resulting in a reduction of sanding efficiency that tends to zero as the amplitude of vibration tends to the eccentricity of the drive axis. A common misconception is that by increasing the contact force an increase in material removal rate can be achieved. As such, counter-intuitive system behaviour in prior-art solutions often results in poor sanding efficiency, and high levels of vibration. It is the aim of the present invention to markedly reduce vibration arising from translating frictional forces, by ensuring that such forces are reacted within a system of sanding surfaces, thereby increasing the sanding efficiency and rate of material removal that can be achieved.

[0006] According to the present invention there is provided a worktool comprising: a principal drive shaft with a sun gear attached thereto; at least two planetary gears distributed about the circumference of the sun gear at substantially equal angular separation; and a carriage for constraining the planetary gears such that they maintain their angular separation about the axis of the principal drive shaft, wherein: each planetary gear has an eccentric axis in addition to its rotational axis constrained by the carriage, such that each planetary gear can drive, in use, a platen around the respective eccentric axis.

[0007] The platens may be freely rotating, or partially constrained from rotating with respect to the carriage thereby fixing the orientation of the platens with respect to one another. Partially constraining the platens in this way permits the use of tessellating platen configurations.

[0008] The worktool may be a sander or a polisher. The principal drive shaft may be connected, optionally through an additional gear mechanism, to an electric motor.

[0009] In order to preserve the dynamic balance of the system, and to ensure that the frictional forces that might cause vibration are mutually resolved, the eccentric axes have a particular phase relationship. The phase difference between any two eccentric axes may be chosen to be $2\pi/n$ radians, wherein n equals the number of planetary gears and is an integer value greater than 1. This relationship ensures that the centre of mass of the combined system does not depart from the principal axis of rotation.

[0010] With the invention, since the translating frictional forces are mutually reacted, vibration transmitted to the user is in principle decoupled from the applied contact force. Similarly, sanding efficiency is not unduly compromised by increasing contact force, permitting higher rates of material removal. This aspect of the present invention compliments user-intuition, unlike the prior art systems described above.

[0011] Furthermore, the arrangement of sanding elements is dynamically balanced, removing the need for the system of counterweights common in conventional sanders. The sanding platens and abrasive surfaces can also be replaced without unduly compromising the dynamic balance.

[0012] The present invention can be configured to be operable in a number of modes, optimising the motion for a given sanding operation or spatial constraint.

[0013] An example of the present invention will now be described with reference to the accompanying drawings, in which:

[0014] Figures 1 and 2 are isometric and plan views of a work tool according to the present invention.

[0015] Figure 3 is a plan view of a device according to the present invention, with an additional gear shown.

[0016] Figure 4 is a plan view showing alternative configurations of the platens only.

[0017] Referring first to figures 1 and 2, there is shown a principal drive shaft 1 and carriage 4, of a worktool, such as a sander, to which a sun gear 2 is attached. A number of planetary gears 3 are distributed about the circumference of the sun gear 2 at equal angular separation. The planetary gears 3 are constrained by a carriage 4, locating the centres and maintaining the angular separation about the principal axis of the drive shaft 1. Each planetary gear 3 has an eccentric axis 5, in addition to the centre of rotation constrained by the carriage 4, driving a freely rotating or partially rotationally constrained platen 6.

[0018] If the platens are partially constrained from rotating then alternative tessellating platen configurations are possible. Some examples of such configurations are shown in Figure 4. With reference to figure 4, each of the platens 8 or 9 can be attached to a respective eccentric axis 5, instead of the circular platen 6 shown in figure 1. Alternatively, in an embodiment that employs four planetary gears 3, a square platen 10 can be attached to each of the respective eccentric axes 5.

[0019] When free to rotate the carriage 4 will be driven by a net torque between the sanding surfaces and the work-piece (not shown) causing the sanding centres to describe a distorted epicycloid where the number of rotations of the respective planetary gear is not purely a function of the sun/planetary gear ratio. This is a random motion most suited to finishing applications.

[0020] If the carriage 4 is prevented from rotating, preferably with a user-engaged lock, the platens 6 will orbit a fixed centre, with no bulk rotation of the combined system. This constitutes a mode of operation suitable for sanding an inside corner that would be inaccessible by an equivalent single sanding platen of an area equal to the sum of the platen areas.

[0021] Figure 3 shows an optimal additional gear 7 composed inwardly facing teeth with engage with each of the planetary gears and is concentric with the principal drive axis 1. When this additional gear 7 is free to rotate, the above modes are accessible. However, when prevented from rotating, again with a user-engaged lock, the platen centres will be driven in a strictly epicyclic motion. This would result in higher surface to surface speeds, and a corresponding increase in the rate of material removal.

Claims

1. A worktool comprising:

   a principal drive shaft with a sun gear attached thereto;

   at least two planetary gears distributed about the circumference of the sun gear at substantially equal angular separation; and

   a carriage for constraining the planetary gears such that they maintain their angular separation about the axis of the principal drive shaft, wherein:

   each planetary gear has an eccentric axis in addition to its rotational axis constrained by the carriage, such that each planetary gear can drive, in use, a platen around the respective eccentric axis.

2. The worktool of claim 1, wherein the phase difference between any two eccentric axes is to be $2\pi/n$ radians, wherein n equals the number of planetary gears and is an integer value greater than 1.

3. The worktool of claim 1, arranged to be a polisher.

4. The worktool of claim 1, arranged to be a sander.

5. The worktool of claim 1, wherein the principal drive shaft is connected to a motor.

6. The worktool of claim 1, wherein the platens can rotate freely.

7. The worktool of claim 1, wherein the platens are partially rotationally constrained.

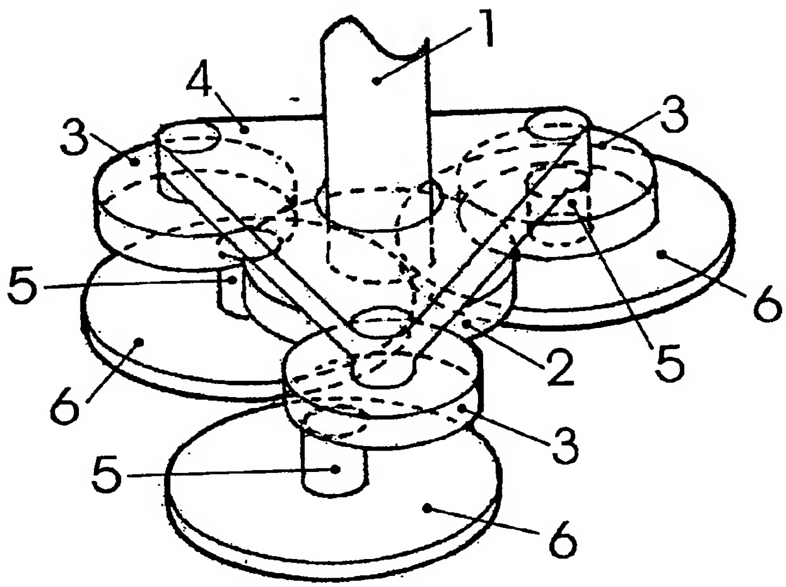

Figure 1

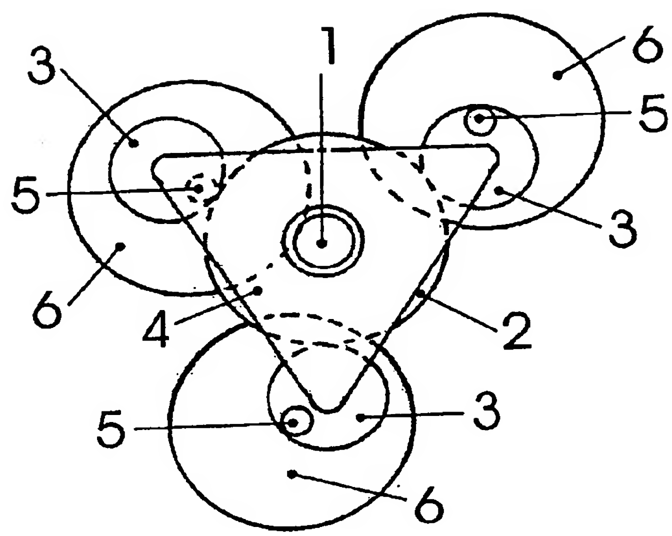

Figure 2

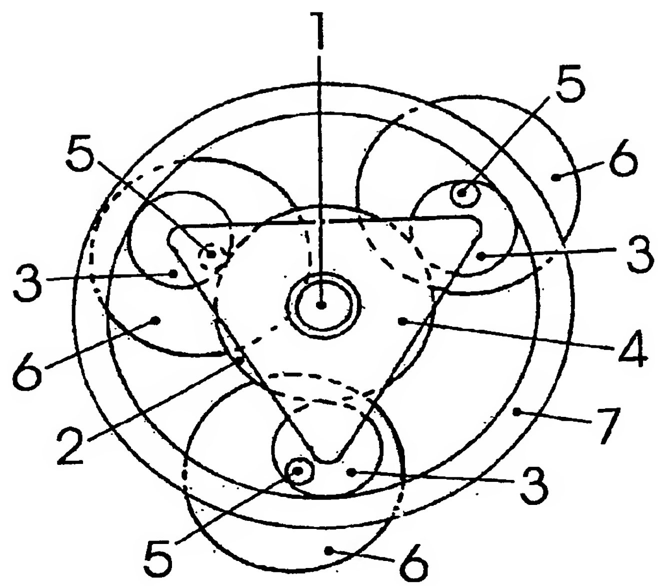

Figure 3

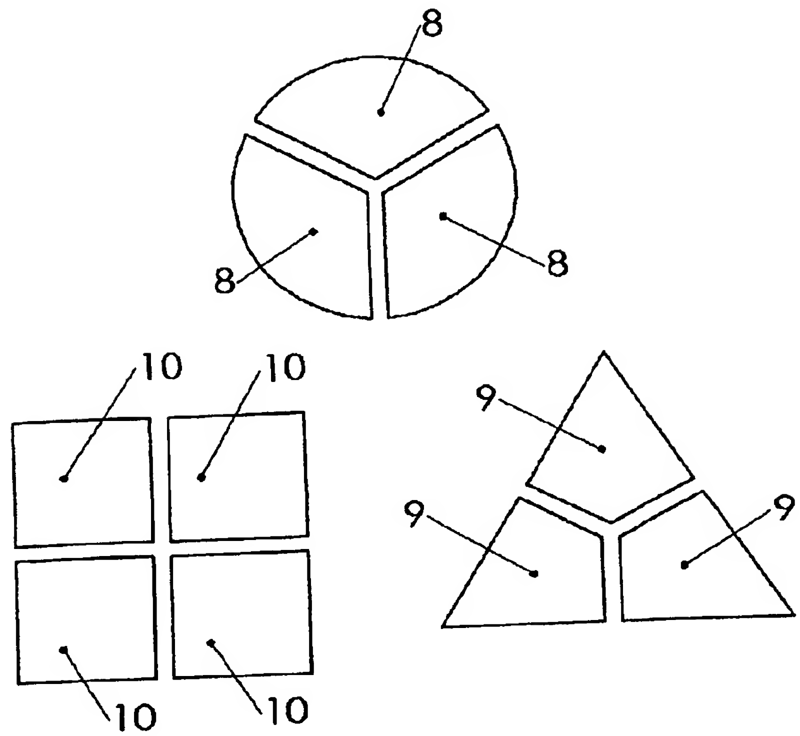

Figure 4

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EUROPEAN SEARCH REPORT

Application Number
EP 02 25 6865

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	DE 930 948 C (MUELLER BRUETSCH & CO ZUERICH) 28 July 1955 (1955-07-28) * page 2, column 1, line 53 - column 2, line 65; figures 1,2 *	1-7	B24B23/03 B24B41/047 B24B7/18
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A	US 2 759 305 A (HELBIG JIM D) 21 August 1956 (1956-08-21) * column 5, line 10 - line 19 * * column 8, line 62 - column 9, line 17; figures 3,8-10 *	2	
A	US 4 097 950 A (SATTERFIELD LARRY S) 4 July 1978 (1978-07-04) * column 1, line 45 - column 2, line 14; figure 2 * * column 2, line 65 - column 3, line 6; figure 3 *	1-5,7	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 December 2002	Do Huu Duc, J

CATEGORY OF CITED DOCUMENTS

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19-12-2002

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82